A new species of *Paryphantopsis* (Gastropoda: Pulmonata: Charopidae) from Crater Mountain, Simbu (Chimbu) Province, Papua New Guinea

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ABSTRACT

Paryphantopsis bradleyi new species is described from a sub-montane forest near Crater Mountain Biological Research Station in Simbu Province, central Papua New Guinea. It is distinguished from its congeners by the combination of its large size and sharply pointed, non-overlapping periostracal processes that are retained to maturity. It shares similarities and is probably closely related to other large *Paryphantopsis* Thiele, 1928, that have angled to carinate shell margins with long periostracal processes and central and lateral radular teeth that have mesocones originating from the center of their basal plates. It appears that much of New Guinea's highly endemic terrestrial snail fauna remains to be discovered. It is imperative that the biodiversity of large groups of taxa is documented because this information will be crucial in efforts to preserve rapidly diminishing rainforest habitat.

Additional keywords: Terrestrial snail, pulmonate, rainforest, taxonomy

INTRODUCTION

The pulmonate snail family Charopidae Hutton, 1884, was once considered to be a minor component of the terrestrial molluscan fauna of New Guinea, in contrast to the group's spectacular radiations in the oceanic islands of the Pacific (Solem, 1983: 305). However, recent surveys in Papua New Guinea suggest that inadequate sampling, rather than low diversity, is the cause of the perceived paucity of charopid species in New Guinea (Slapcinsky, 2005). *Paryphantopsis* Thiele, 1928, the most diverse genus of charopids in New Guinea, consists of 26 described species distributed from Papua (Irian Jaya) to the Louisiade Archipelago and New Britain. Solem (1970) reviewed the 14 species of the genus then known, redescribing all species except those described or reviewed by van Benthem Jutting (1964). However, nearly half of this radiation has been described only recently (Slapcinsky, 2005, 2006; Slapcinsky and Lasley, 2007), and it is clear that continued sampling, especially in New Guinea's poorly sampled mountain ranges, will uncover many additional species. All *Paryphantopsis* species are restricted to single mountain ranges, each often supporting several *Paryphantopsis* species. The most widely distributed species, *Paryphantopsis yawii* Slapcinsky, 2005, ranges 50 km along the mountains of the East Cape Peninsula in extreme eastern Papua New Guinea. Synapomorphies in *Paryphantopsis* from the same mountain ranges suggest they have speciated on a fine geographic scale (Slapcinsky, 2005).

Most *Paryphantopsis* species occur in moist and mossy montane and sub-montane forests or at lower elevations in hill forest along stream valleys. Restriction to stable moist habitats and microhabitats might promote genetic isolation and rapid speciation in the group. Species of *Paryphantopsis* are unusual in being diurnally active (Slapcinsky and Lasley, 2007) and having reduced shells of approximately three whorls compared to at least four whorls in most other charopids. Whorl reduction is associated with enlargement of the shell aperture, modifications of the kidney, and reduced space in the pallial cavity for retraction of the visceral hump (Solem, 1970). All of these traits may make *Paryphantopsis* especially susceptible to desiccation if their moist forest habitats are altered. Besides shell whorl reduction and the associated changes in pallial organs, *Paryphantopsis* is also diagnosed by the following shell synapomorphies: protoconch sculpture of axial and spiral riblets that usually coalesce forming spiral rows of pits, growth lines that are accentuated with rib-like periostracal extensions that often bear processes at the shell margin, and shells that are not openly umbilicate.

Between 1990 and 1993, the Florida Museum of Natural History received a collection of terrestrial snails collected by Andy Mack and Debra Wright during studies at Crater Mountain Biological Research Station. This collection included a new species of *Paryphantopsis* which

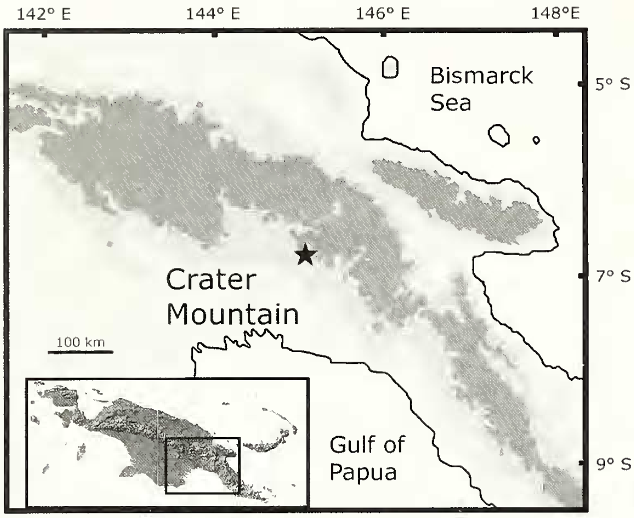
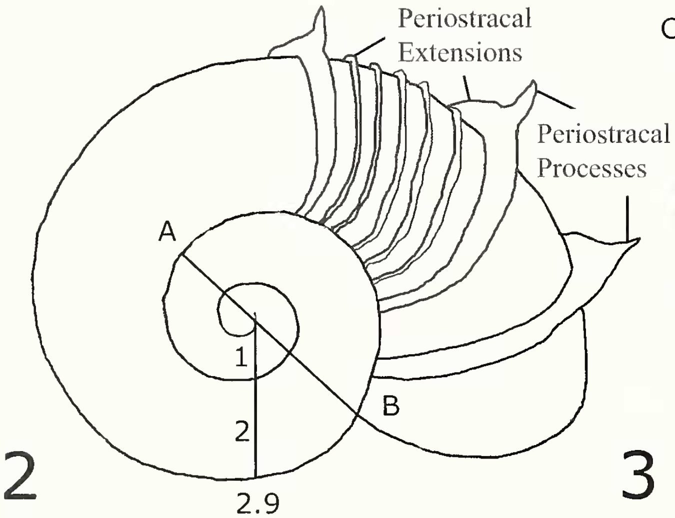


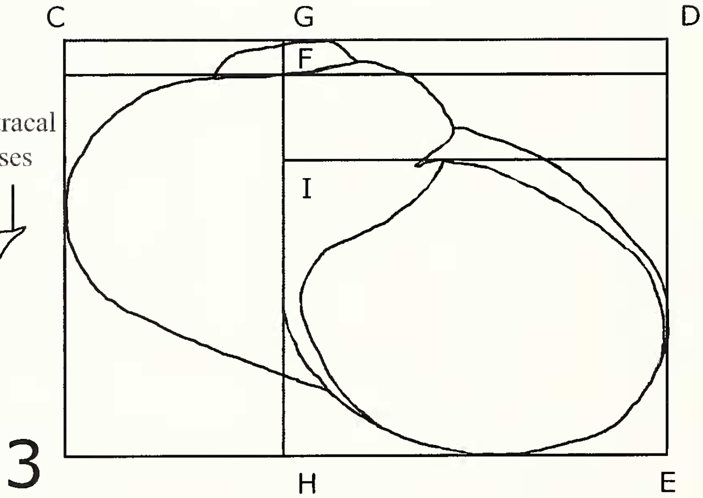
Figure 1. Map of eastern New Guinea showing the type locality of *Paryphantopsis bradleyi* new species

is described here. Crater Mountain Biological Research Station is located in southeastern Simbu Province, Papua New Guinea, approximately 78 km SSW of Goroka and 11 km E of Haia Village, at 6.72° S, 145.09° E (Figure 1). The research station is located on the southern slope of Crater Mountain, an arcuate chain of peaks reaching 3000 m or more in elevation and formed from an extensively eroded stratovolcano last active in the late Pleistocene or early Holocene (Mackenzie and Johnson, 1984). The topography of Crater Mountain is extreme, with vertical cliffs and frequent seismic activity, which, combined with ample rainfall results in numerous treefalls and landslides, lead to heterogeneous habitats and microhabitats. Geographic and habitat heterogeneity may contribute to the floristic richness of the area, the richest site known in New Guinea and among the richest in the world (Wright et al., 1997). A 1 ha plot contained 228 tree and liana species with no strongly dominant species. This floristically and geologically diverse site has not previously been sampled for terrestrial snails and is likely to sustain additional undiscovered species.

MATERIALS AND TEXT CONVENTIONS

Specimens were hand-collected or sifted from samples of leaf-litter. Live-collected animals were drowned and then preserved in 75% ethanol. Gross anatomical dissections were made under 75% ethanol using a dissecting microscope. Radulae were isolated from dissected buccal masses using a 5% sodium hypochlorite solution. Scanning electron micrographs of radulae were made using a Field Emission-SEM. Measurements were taken using an ocular micrometer. Whorl count was measured from the suture of the first whorl to the body whorl and fractions of a whorl were determined with the aid of a cardboard circle divided into ten equal parts of 36° (Figure 2, line 1–2.9). Spire width was the length of a straight line passing from the apertural edge of the suture through the middle of the apex to the opposite suture (Figure 2, line A–B). Shell width was the greatest width of the shell perpendicular to the shell axis (Figure 3, line C–D). Shell height was the greatest distance between the apex and the base of the aperture measured parallel to the shell axis (Figure 3, line D–E). Spire height was measured from the top of the body whorl to the apex of the shell (Figure 3, line F–G). Aperture width was the greatest distance from the columellar edge to the outer edge of the aperture (Figure 3, line E–H). Aperture height was measured from the suture to the base of the aperture, parallel to the shell axis (Figure 3, line H–I). Shell measurements are based on nine unbroken adults; ranges are followed by mean and standard deviation. The lengths of radular teeth





Figures 2–3. Diagrams of shell measurements. **2.** Whorl count (line 1–2.9), spire width (line A–B). **3.** Shell width (line C–D), shell height (line D–E), spire height (line F–G), aperture width (line E–H), aperture height (line H–I).

were measured from the top of the mesocone to the posterior edge of the basal plate. The widths of radular teeth were measured as the greatest width of the cusps, not the basal plate. The following abbreviations are used in figures of genital anatomy: AT = atrium, BC = bursa copulatrix, BT = bursa tract, EP = epiphallus, PE = penis, PP = penial pilaster, PR = penial retractor muscle, SO = spermoviduct, V = verge, VA = vagina, and VD = vas deferens. All specimens are deposited in the Florida Museum of Natural History, Gainesville (UF).

SYSTEMATICS

Family Charopidae Hutton, 1884
Genus *Paryphantopsis* Thiele, 1928

Type species: *Flammulina* (*Paryphantopsis*) *lamelligera* Thiele, 1928, by original designation.

Paryphantopsis bradleyi new species
(Figures 4–10)

Holotype: UF 378116 (dry shell), Papua New Guinea, Simbu Province, 78 km SSW of Goroka, 11 km E of Haia Village, Crater Mountain Biological Research Station, approximately 6.72° S, 145.09° E., 1100 m altitude, D. Wright, 6 Apr. 1992.

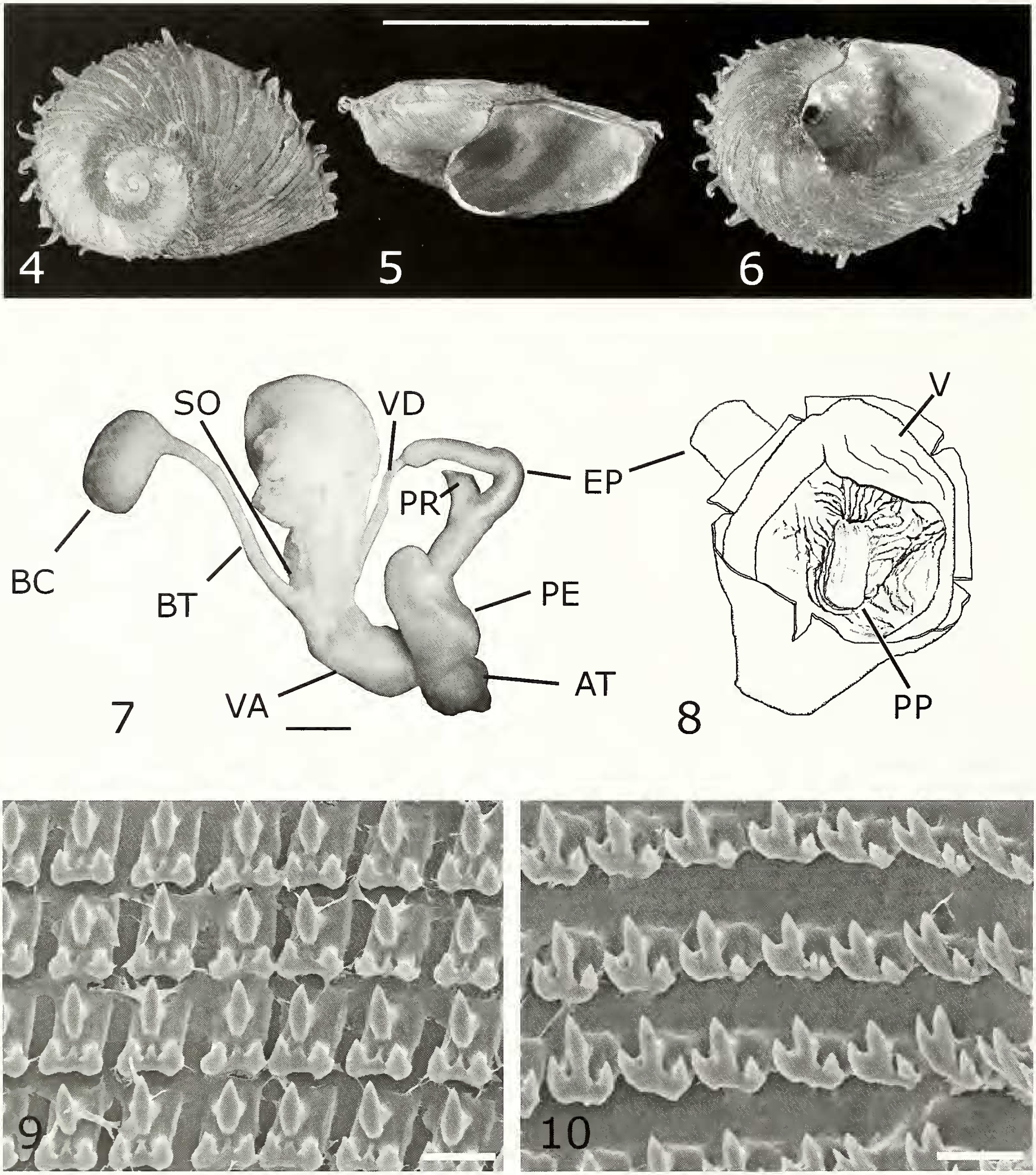
Paratypes: Type locality: UF 274062 (1 alcohol-preserved), UF 378115 (1 dry shell), 1100 m, D. Wright, 7 August 1991; UF 274059 (2 alcohol-preserved), UF 420747 (2 dry shells), 1350 m, D. Wright, 21 April 1992; UF 274061 (2 alcohol-preserved), 1100 m, D. Wright, 6 April 1992; UF 274057 (1 alcohol preserved), 1130 m, D. Wright, 18 March 1992; UF 179660 (1 alcohol preserved), 1160 m, D. Wright, 1 July 1990; UF 274060 (1 alcohol-preserved), A. Mack, 25 January 1993; UF 274058 (1 alcohol preserved), UF378114 (1 dry shell), A. Mack; UF 274056 (1 alcohol-preserved), A. Mack; UF 179657 (1 juvenile, alcohol-preserved), 1130 m., D. Wright.

Description: Adult shell depressed; large for genus, 9.1–11.3 mm (10.3±0.8) in width and 4.1–5.9 mm (5.2±0.6) in height, with 2.8–3.1 (2.9±0.1) rapidly expanding whorls (Figures 4–6). Suture impressed and broadly channeled. Apical surface of whorls flattened between suture and periphery. Shell periphery angular to carinate above mid-point and rounded below, flattening abruptly basally. Spire flat or only slightly elevated, 0.0–0.3 mm (0.1±0.1) and narrow 3.4–4.1 mm (3.7±0.2) only 0.3–0.4 (0.36±0.02) of shell width. Teleoconch whorls do not descend or descend only slightly. shell height/diameter ratio 0.4–0.6 (0.50±0.04). Approximately 1.7 flattened protoconch whorls sculptured with about 12–17 rows of spiral pits that continue on teleoconch becoming elongate and less regular. These pits are obscured by thick periostracum on teleoconch but can be observed in aperture through translucent shell. Teleoconch whorls have growth lines accentuated with short periostracal extensions. Approximately every fifth extension longer and bearing a triangular process (approximately 1.0–1.5 mm long) at shell margin. These processes are retained to maturation. Protoconch whitish to tan. Teleoconch whorls brown; first 2.5 whorls darkest below suture and last 0.5 whorl dark throughout. A reflection of peristome completely covers umbilicus at all stages of growth. Aperture is ovate to almost quadrate and very large with an aperture-height to aperture-width ratio of 0.4–0.7 mm (0.63±0.10).

Epiphallus 3× diameter of vas deferens, only slightly inflated apically, widening gradually basally, folded approximately at mid-point, and does not bear an apical diverticulum (Figure 7). Penial retractor muscle short and robust, originating from diaphragm and inserting on epiphallus half way between epiphallar fold and junction with penis. Penis ovate and slightly inflated basally; epiphallus joins it laterally just below rounded apex. Penis width is 0.5× length and 2–3× width of epiphallus. Penis wall thin and smooth and interior of retracted penis containing large verge that, when unfolded, is bowl-shaped (Figure 8). Interior of verge is sculptured with tongue-shaped pilaster that extends from epiphallar opening to near base of penis. Atrium short and broad, with nearly same diameter as penis. Vagina relatively long, with about same length and only slightly narrower than penis. Free oviduct short, and with nearly same width as and poorly differentiated from vagina. Base of bursa tract narrow, its diameter only 0.3× diameter of free oviduct where they meet, rapidly narrowing to 0.2× diameter, and remaining narrow to junction with bursa copulatrix.

Central and first lateral teeth of radula are tricuspid, 9–10 μm wide, and 11–12 μm long (Figure 9). Mesocones of central teeth and lateral teeth tall and slender, projecting slightly beyond their basal plates, and originating from center of their basal plates rather than from a ridge on posterior edge of basal plate as in most other *Paryphantopsis* species. Ectocones of central teeth trigonal and symmetric. Ectocones and endocones of lateral teeth are trigonal and about 0.5× height of mesocones. Endocones and ectocones of lateral teeth nearly symmetrical, endocones very slightly larger but otherwise of similar shape to their ectocones. First 15 teeth to left and right of central row are similar to first lateral teeth, next two teeth on either side grade in shape and are difficult to classify as either lateral or marginal teeth. Last seven teeth clearly marginal and dorsoventrally compressed, 11–12 μm wide and 8–9 μm long (Figure 10). Endocones of marginals unicuspid and about 0.7× as tall as mesocones. Ectocones are unicuspid to irregularly multicuspid and much shorter, about 0.5× as tall as mesocones.

Habitat: All specimens were collected from sub-montane forest (Paijmans, 1976) between 1100 and 1350 m elevation in leaf litter and on live leaves especially of Zingiberaceae within 1 m of the ground. Vegetation



Figures 4–10. *Paryphantopsis bradleyi* new species. **4–6.** Photographs of shell, holotype UF 378116, diameter 11.3 mm. Scale bar = 10 mm. **7.** Photograph of genitalia, UF 274062. Scale bar = 1 mm. **8.** Drawing of penis interior, UF 274062. **9–10.** Scanning electron micrograph of radula, UF 274062. Scale bars = 10 m.

at the type locality consisted of mature uncut forest with a few small patches of late secondary growth from abandoned gardens. Mean annual rainfall is 6400 mm and is evenly distributed throughout the year. Diurnal temperatures are 15–28° C. The area's soils range from dark brown loam to orange clay with variable soil nutrients including soil calcium that ranges from 270 to 1560 ppm (Wright et al., 1997).

Etymology: This patronym honors botanist Ted Bradley, Santo Domingo de Heredia, Costa Rica (retired from George Mason University, Fairfax, Virginia) my friend, teacher, and field companion who encouraged my interest in taxonomy and introduced me to the rich and underreported diversity of the tropics.

Remarks: *Paryphantopsis bradleyi* new species is one of the largest species in the genus and is similar in size only to *P. louisiadarum* (Möllendorff, 1899) and *P. globosa* (Hedley, 1890), both of which differ in having shells with rounded margins that lack periostracal processes. *Paryphantopsis bradleyi* appears similar to species that have shells with angulate to carinate margins and that bear periostracal processes that are retained in adults: *P. corolla* Slapcinsky and Lasley, 2007, *P. elegans* (Fulton, 1902), *P. fultoni* (Coen, 1922), *P. lamelligera* (Thiele, 1928), *P. lebasii* Slapcinsky, 2005, *P. yawii* Slapcinsky, 2005, and *P. yelensis* Slapcinsky, 2006. The periostracal processes of *P. elegans*, *P. fultoni*, and *P. yawii* overlap, forming a continuous serrated edge at the shell margin, while the periostracal processes of *P. bradleyi*, *P. lamelligera*, and *P. yelensis* each taper to a point, unlike the rounded processes of *P. lebasii*. Of the species for which the genital anatomy is known, *P. bradleyi* is similar to *P. lamelligera*, *P. lebasii*, and *P. yawii* in lacking an apical diverticulum on the epiphallus, unlike *P. corolla* and *P. yelensis*. The mesocones of both the central and lateral teeth of the radula of *P. bradleyi* join the basal plate near its center as in *P. lebasii*, *P. yawii*, and *P. yelensis*, and unlike *P. corolla*.

DISCUSSION

Unlike that of many other taxa, species diversity of terrestrial snails has been considered to be low in tropical rainforests (Solem, 1984). However, recent surveys have demonstrated that terrestrial snails are often diverse in tropical rainforests (Winter and Gittenberger, 1998; Schilthuizen and Rutjes, 2001) and it appears that low abundance and sampling intensity are the reasons for perceived low diversity of snails in rainforests. Lack of sampling is particularly troubling because rapid deforestation is leading to the extinction of narrowly endemic snail species in many tropical forests (Emberton, 1995; Emberton et al., 1997). Unfortunately, non-marine mollusks appear to be particularly prone to extinction, constituting an alarming 42% of the recorded extinctions of animal species since the year 1500 (Lydeard et al., 2004). Much more of this loss may go unreported because terrestrial snails receive relatively little taxonomic study in relation to their diversity. Indeed, there are approximately 24,000 described species and an estimated 11,000 to 40,000 undescribed species (Lydeard et al., 2004). The land snail fauna of New Guinea appears to be especially diverse but few of its mountain ranges have ever been surveyed for most invertebrate groups. These mountains support diverse and highly endemic snail faunas that are only now being discovered (Slapcinsky, 2005). New Guinea sustains the largest tracts of tropical broadleaf forest remaining in Australasia and the third largest on the planet after the Amazon and Congo forests (Brooks et al., 2006). More than 71% of Papua New Guinea is forested and 57% of this forest is commercially valuable and globally imperiled lowland rainforest (Shearman et al., 2008). These resources will come under increasing commercial and developmental pressures as other forests in the region are exhausted. Already, the rate of deforestation in Papua New Guinea is higher than previously believed, and is accelerating, and if these rates continue it is estimated that 83% of the country's forests will be cleared or degraded by 2021 (Shearman et al., 2008). The loss of these forests will result in the extinction of endemic species dependant on forest habitat, many before they are ever discovered. Future efforts to preserve rapidly dwindling forests will depend on documentation of their rich biota.

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